

Current Knowledge and Conservation Status of *Arabis falcifructa* Rollins (Brassicaceae), the Elko rockcress.

by James D. Morefield

Nevada Natural Heritage Program, Department of Conservation and Natural Resources,
1550 East College Parkway, suite 145, Carson City, NV 89706-7921. (775) 687 4245

November 1997

(minor editorial revisions June 2002)

Status report prepared for
Bureau of Land Management, Nevada State Office
1340 Financial Boulevard, Reno, NV 89502. (775) 861 6300

SUMMARY: *Arabis falcifructa* was first discovered and collected in 1945 by Dwight D. Ripley and Rupert C. Barneby near San Jacinto along the highway between Wells and Jackpot (now U.S. 93) in northeastern Elko County, Nevada. Reed C. Rollins and Kathryn W. Rollins collected the type specimen in 1979 about 30 miles farther south along the same highway, and Reed named it as a new species in 1982. It is a perennial herb with a branched root crown, long, narrow, crowded, grayish-white basal leaves, sparsely leafy flowering stems up to half a meter tall, small pale-purple flowers, and long, narrow fruits that curve outward and downward from the stem. *Arabis falcifructa* remains endemic to Nevada, mainly in the Salmon Falls Creek basin of northeast Elko County, with a single disjunct site in the Shoshone Mountains of southwestern Lander County. *Arabis falcifructa* showed possible evidence of hybridization with *A. sparsiflora* at one site, but otherwise appears to be a distinct species closely related to that species and to *A. cobrensis*.

As of the end of 1990, *Arabis falcifructa* was known from 3 populations in the Salmon Falls Creek basin and the Shoshone Mountains between 5300 and 6000 feet (1615—1830 meters) elevation. All of these sites were small, near roads on public lands open to multiple uses, and already somewhat impacted by livestock grazing and road construction. Because of these impacts and its rarity and continued vulnerability, *Arabis falcifructa* was designated a category-2 candidate for federal listing on 21 February 1990. Responding to this concern, the U. S. D. I. Bureau of Land Management (BLM) and the Nevada Natural Heritage Program sponsored and conducted field surveys in 1991—1992 and 1997 to verify and refine the historical reports, discover any additional populations, and document the biology, ecology, and conservation status of all populations. This report summarizes the results of these surveys, reviews all previous knowledge of the species, and recommends conservation and recovery actions designed to prevent it from becoming a threatened or endangered species.

The surveys conducted for this report increased the known extent of *Arabis falcifructa* by 6 populations (200%) and 28.4 acres (11.5 ha; 182%). As now documented, *Arabis falcifructa* is known worldwide from 9 populations in 3 scattered areas, totaling about 606 plants and covering about 38.5 acres (15.6 ha) of BLM and possibly Nevada Department of Transportation lands between 5300 and 6100 feet (1615—1860 meters) elevation. *Arabis falcifructa* was restricted to light-colored silty soils with a high cover of moss, derived from volcanic ash and tuff deposits on dry, relatively undisturbed, moderate to steep northerly aspects (possibly including rock crevices at one poorly documented site). The habitat supported a relatively dense shrub-steppe association usually dominated by Wyoming sagebrush and soil-surface moss in association with pinyon rabbitbrush, hopsage, western bluegrass, Indian ricegrass, and cushion buckwheat. *Arabis*

falcifructa appeared to depend on the intact soil-surface moss cover for successful reproduction and/or survival at one or more stages of its life cycle. Surveys focusing on about 1043 acres (422 ha) of additional potential habitat in Elko and Lander counties revealed no further populations of *Arabis falcifructa*, but several hundred to several thousand acres of potential habitat remain unsurveyed, and the true global population of the species is estimated to be 2—10 times larger than that now documented.

The habitat of *Arabis falcifructa* is relatively attractive to grazing livestock, and the dense moss cover on which the species appears to depend is highly vulnerable to, and slow to recover from, concentrated animal trampling. As of this report, significant impacts from livestock trampling and/or road construction and maintenance had been observed at 6 (67%) of the known populations, apparently compromising the viability of at least one of these. The habitat is also vulnerable to fire, fire suppression activities, and invasive weed infestations, though no impacts from these sources have yet been observed. *Arabis falcifructa* appeared incapable of colonizing even moderate disturbances within its specific habitat, requiring stable substrate conditions for its long-term viability. The species may depend on insect pollinators for at least part of its reproductive success, but nothing is known about the identity, specificity, rarity, status, current effectiveness, or viability trends of these pollinators. Currently *Arabis falcifructa* is managed as a sensitive Special Status Species by the BLM, but has no other legal status or protective designation.

Based on the best available scientific evidence, and the likelihood that additional undocumented populations exist, *Arabis falcifructa* does not yet meet the definition of a candidate for listing as threatened or endangered under the Endangered Species Act, but would meet that definition if further surveys revealed few or no additional populations. Such surveys are needed immediately. Its long-term viability remains in doubt without protective management, and it could become a threatened or endangered species if one or more populations were lost. It therefore continues to meet criteria for Sensitive Species designation by the BLM. This report recommends several conservation and recovery measures which, if successfully implemented, offer the best chance to eliminate any future need to list *Arabis falcifructa* as threatened or endangered. Primary among these are corrective grazing management, long-term monitoring, continued surveys of potential habitat, careful design of future projects to avoid further impacts, aggressive management of invasive weeds on a local and regional basis, and study of insect pollinators.

ACKNOWLEDGMENTS

Roy Price (Elko District BLM) generously opened his home to me at various times during surveys for this report. Kim Goodwin (Nevada Natural Heritage Program) helped with mapping and data processing. The herbaria cited in appendix 1, table 5, and their curators and parent institutions, maintained and made available the specimens in their care. I am grateful to all of these people for their contributions to this report, and none of them is responsible for any of the opinions or judgments expressed herein, nor for any errors that may remain.

All information contained in this report was believed current and complete on the date it was printed. Please submit any and all additions, corrections, updates, comments, or suggestions, whatever their magnitude, to either of the addresses above.

TABLE OF CONTENTS

SUMMARY.....	1
ACKNOWLEDGMENTS	2
TABLE OF CONTENTS	3
 I. CLASSIFICATION AND SYSTEMATICS	6
Scientific Name and Citation.....	6
Type Specimen.....	6
Synonym(s)	6
Vernacular Name(s)	6
Family.....	6
Major Groups	6
Review of Alternative Taxonomic Treatments	6
Biogeography and Phylogeny	7
 II. TAXON HISTORY	7
 III. PRESENT LEGAL OR OTHER FORMAL STATUS.....	7
International	7
Federal.....	8
State	8
 IV. DESCRIPTION	8
Non-technical	8
Technical	8
Field Characters	9
Photographs and Line Drawings.....	10
 V. SIGNIFICANCE OF TAXON	10
Natural.....	10
Human	10
 VI. GEOGRAPHIC DISTRIBUTION	10
Geographic Range.....	10
Precise Occurrences	11
Historical site(s) rediscovered or recently known extant	11
New site(s) discovered	11
Historical site(s) searched for but not rediscovered	11
Other site(s) searched where not discovered	12
Historical site(s) known or suspected to be erroneous reports	12
Historical site(s) known or assumed extirpated	12
Historical site(s) where present status unknown	12
Potential site(s) meriting future field surveys	12
 VII. HABITAT CHARACTERISTICS	12
Environment and Habitat Summary	12

Physical Characteristics	13
Physiography	13
Climate.....	13
Geomorphology, aspect, and slope	14
Geology	14
Soils	14
Hydrology	14
Air and water quality requirements.....	14
Biologic Characteristics	15
Community physiognomy	15
Vegetation type.....	15
Associated plant species.....	15
Other endangered, threatened, and sensitive species.....	15
Land Management	15
 VIII. BIOLOGY AND ECOLOGY	 16
Population Summary	16
Demography	16
Phenology.....	16
Genetics.....	17
Reproduction and Dispersal.....	17
Hybridization	17
Pathology.....	17
Predation	18
Competition.....	18
Response to Disturbance.....	18
Other Interactions.....	18
 IX. EVIDENCE OF THREATS TO SURVIVAL	 18
Present or threatened destruction, modification, or curtailment of habitat/range.....	18
Over-utilization for commercial, recreational, scientific, or educational purposes....	19
Disease or Predation	20
Inadequacy of Existing Regulatory Mechanisms	20
Other Natural or Man-made Factors.....	21
 X. GENERAL ASSESSMENT AND RECOMMENDATIONS	 21
General Assessment	21
Status Recommendations.....	21
Critical Habitat Recommendations.....	22
Conservation and Recovery Recommendations.....	22
 XI. INFORMATION SOURCES	 24
Literature Cited	24
Map Sources.....	26
Field Research.....	27
Specimens	27
Knowledgeable/Interested Individuals	27—28

APPENDIX 1. TABLES.

- Table 1. Documented *Arabis falcifructa* sites.
- Table 2. Sites searched where unoccupied by *Arabis falcifructa*.
- Table 3. Plant species observed at selected *Arabis falcifructa* sites.
- Table 4. Status of other endangered, threatened, sensitive, and watch-list species reported in and near the geographic range of *Arabis falcifructa*.
- Table 5. Specimens documenting known and reported *Arabis falcifructa* sites.

APPENDIX 2. FIGURES.

- Figure 1. Composite line drawing approximating *Arabis falcifructa*.
- Figure 2. Line drawings of *Arabis cobrensis* and *Arabis sparsiflora*, two species superficially similar to *Arabis falcifructa* and sometimes confused in the field.
- Figure 3. Basal leaves of *Arabis falcifructa* at site 2, showing surrounding moss cover, plants in late fruit on 26 July 1991.
- Figure 4. View of entire individual of *Arabis falcifructa* shown in figure 3.
- Figure 5. Habitat of *Arabis falcifructa*, showing surrounding moss cover, individual from figure 3 in foreground.

APPENDIX 3. MAPS.

- Map 1. Global distribution of *Arabis falcifructa*, Elko and Lander counties, Nevada.
- Map 2. *Arabis falcifructa* site 1 (approximate) and unoccupied site U1, Harris Canyon and Wilkins 1:24,000 quadrangles. All maps are in Elko County, Nevada, unless otherwise noted.
- Map 3. *Arabis falcifructa* sites 2 and 6, and unoccupied sites U2—U4, Jackpot 1:24,000 quadrangle.
- Map 4. *Arabis falcifructa* site 3 and unoccupied site U5, Mount Airy NE 1:24,000 quadrangle, **Lander County**.
- Map 5. *Arabis falcifructa* sites 4—5 and unoccupied site U6, Harris Canyon 1:24,000 quadrangle.
- Map 6. *Arabis falcifructa* site 7 and unoccupied site U7, Middle Stack Mountain 1:24,000 quadrangle.
- Map 7. *Arabis falcifructa* site 8 and unoccupied site U8, Knoll Mountain 1:24,000 quadrangle.
- Map 8. *Arabis falcifructa* site 9 and unoccupied sites U9—U11, Wilkins 1:24,000 quad.
- Map 9. Sites U12—U13 unoccupied by *Arabis falcifructa*, Jackpot 1:24,000 quad.
- Map 10. Site U14 unoccupied by *Arabis falcifructa*, Middle Stack Mountain 1:24,000 quadrangle.
- Map 11. Site U15 unoccupied by *Arabis falcifructa*, Contact 1:24,000 quadrangle.
- Map 12. Sites U16—U17 unoccupied by *Arabis falcifructa*, Vigus Butte NW 1:24,000 quadrangle, **Lander County**.

I. CLASSIFICATION AND SYSTEMATICS

Scientific Name: *Arabis falcifructa* Rollins (1982, p. 112—113).

Type Specimen: NEVADA, Elko County: in crevices of rocks, sagebrush area on slope of a high ridge, near U.S. Hwy. 93 between Thousand Springs and Jackpot, 37 miles south of Jackpot, 18 June 1979, *R. C. Rollins & K. W. Rollins* 79267 (holotype: GH; isotype: NY) (Rollins 1982, Tiehm 1996).

Synonym(s): No known synonymy or synonyms have been proposed for *Arabis falcifructa*. Prior to its recognition as a distinct species, specimens had been identified as *Arabis cobrensis* M. E. Jones (Rollins 1982).

Vernacular Name(s): Elko rockcress.

Family: Brassicaceae (mustard family). Alternate name: Cruciferae.

Major Groups:	Cronquist (1988)	Thorne (1992)
Class	Magnoliopsida (Dicotyledoneae)	Magnoliopsida (Angiospermae)
Subclass	Dilleniidae	Magnoliidae (Dicotyledoneae)
Superorder	————	Violanae
Order	Capparales	Brassicales

Review of Alternative Taxonomic Treatments: Specimens described by Rollins (1982) as *Arabis falcifructa* were previously identified as *A. cobrensis* M. E. Jones, which remains its closest known relative. Rollins (1982) noted several correlated character states separating the two species, and no alternative treatments have since been proposed. *Arabis falcifructa* appears to be universally accepted as a distinct species.

During surveys for this report, plants of *Arabis cobrensis*, *A. falcifructa*, and *A. sparsiflora* Nuttall ex Torrey & A. Gray var. *sparsiflora* were found growing intermingled at the Thousand Springs Valley 5973 site (site 9), and one plant assigned to *A. sparsiflora* var. *sparsiflora* exhibited some characteristics intermediate with *A. falcifructa*. Because of the low numbers and densities of the *Arabis* populations at all sites, it was impossible to determine whether this represented a case of incomplete speciation, or of secondary contact and hybridization. It did, however, suggest the possible parentage of hybrids from which *Arabis falcifructa* could subsequently have evolved. *Arabis falcifructa* is intermediate between *A. cobrensis* and *A. sparsiflora* in several characters of the fruit and flowers.

Aside from this one isolated observation, all field work for this report indicated that *Arabis falcifructa* was a distinct, independently reproducing species. *Arabis falcifructa* occurred with other related *Arabis* species at all other sites surveyed (appendix 1, table 3), and was uniformly distinct at those sites.

Biogeography and Phylogeny: The genus *Arabis* Linnaeus consists of about 120 species distributed nearly throughout temperate North America, Eurasia, and Africa (Rollins 1993a), but apparently most abundant and diverse in the western United States, where it is also perhaps the best studied. It belongs to the tribe Arabideae of the mustard family (Brassicaceae), where its closest relatives appear to include *Sibara* E. L. Greene and other smaller genera (Rollins 1941).

No detailed studies of the origin and evolution of the genus *Arabis*, much less of *Arabis falcifructa*, are known to exist. Within the genus, *Arabis falcifructa* appears most closely related to *A. cobrensis* and *A. bodiensis* Rollins (1982). An isolated field observation (see above) suggested that *Arabis falcifructa* could have originated from hybrids between *A. cobrensis* and *A. sparsiflora*. Until further studies are conducted, it is impossible to speculate further as to the more ancient origins of *Arabis falcifructa* and its relatives.

II. TAXON HISTORY

Unless otherwise cited, reports and correspondence documenting the following chronology are on file with the Nevada Natural Heritage Program.

- 1945: First discovered and collected by H. Dwight D. Ripley and Rupert C. Barneby near San Jacinto, south of Jackpot, Elko County, Nevada, on 30 May (Rollins 1982).
- 1979: Next collected simultaneously at the type locality north of Thousand Springs in Elko County, Nevada, by Reed C. and Kathryn W. Rollins, and in the Shoshone Mountains northwest of Austin, Lander County, Nevada, by Sherel Goodrich, on 18 June (Rollins 1982). Identified as *Arabis cobrensis* by Rollins.
- 1982: Formally described as a distinct species by Rollins (1982).
- 1987: Included and recognized in Kartesz's (1987) flora of Nevada, based on Rollins (1982).
- 1990: Designated a category-2 candidate for listing under the Endangered Species Act on 21 February (U. S. D. I. Fish and Wildlife Service 1990).
- 1991—1997: Field surveys conducted by the Nevada Natural Heritage Program.
- 1993: Treated as a distinct species in Rollins (1993b) book on North American Cruciferae.
- 1996: Category-2 candidate designations eliminated for all species on 28 February by the U. S. D. I. Fish and Wildlife Service (1996), all in Nevada provisionally designated Sensitive Species by the U. S. D. I. Bureau of Land Management (1996).
- 1997: Formally designated as a sensitive Special Status Species by the Nevada State Director of the U. S. D. I. Bureau of Land Management (1997).

III. PRESENT LEGAL OR OTHER FORMAL STATUS

International: Using a system established by The Nature Conservancy, the various state natural heritage programs rank sensitive taxa at state, national, and global levels on a scale of 1 to 5, 1 being the most vulnerable and 5 the most secure. *Arabis falcifructa* was most recently ranked 1 by the Nevada Natural Heritage Program at all levels (Morefield and Knight 1992). The results of this report show 1—2 to be the more appropriate rank at all levels.

Federal: Until February 1996 *Arabis falcifructa* was designated a category-2 candidate for listing as endangered or threatened under 16 U.S.C. 1531 *et seq.*, the Endangered Species Act as amended in 1988. Category-2 included taxa for which "*proposing to list as threatened or endangered is possibly appropriate, but for which sufficient data on biological vulnerability and threats are not currently available to support proposed rules*" (U. S. D. I. Fish and Wildlife Service 1993). Use of that category was discontinued by the U. S. D. I. Fish and Wildlife Service (1996). *Arabis falcifructa* is on the sensitive species list of the U. S. D. I. Bureau of Land Management (1996, 1997). This report recommends no change to that designation.

State: No formal status designations exist at the state level. *Arabis falcifructa* is on the Northern Nevada Native Plant Society's Watch list (Morefield and Knight 1992). This report recommends no change to that designation.

IV. DESCRIPTION

Non-technical: **Perennial** herb to 5 dm high, hairs mostly minute, multibranched; **root crown** mostly loosely much-branched; **overall color** grayish-green to reddish-tan with pale purple flowers. **Stems** 20—50 cm long, round in cross section, upright, usually many from base, unbranched or branched toward top, densely and minutely hairy below, becoming hairless above. **Leaves** at base and on stem, alternate, flat, unlobed, smooth-edged, upright; leaves at base tufted, many, 1.5—5 cm long, 1.5—3.5 mm wide, very narrow, widest above middle, long-pointed, 1-nerved, stalked, densely, evenly, and minutely whitish- to grayish-hairy; stem leaves few, sparse, unstalked, 0.8—3.5 cm long, 1.5—3 mm wide, narrowly oval, pointed, shortly lobed at base, lower densely and minutely hairy, upper less hairy; **stipules** none. **Flowers** (April—June) upright, several in two loose rows at end of each stem, flower parts soon breaking off; **leaves at stalk base** none; **stalk** in fruit 7—10 mm long, angled straight outward at base, then curving gently downward, minutely hairy to hairless; **outer flower parts** 4, separate, upright, about 3—4 mm long, about 1.5—2 mm wide, not pouched at base, oval, greenish to reddish tan, minutely hairy to hairless, edges narrowly papery; **petals** 4, separate, upright, 5—7 mm long, about 2—3 mm wide, narrowly spoon-shaped, pale purple; **stamens** 6, 2 shorter than the rest, shorter than the petals; **ovary** free to base from surrounding flower parts; **style** in fruit 0.5—1 mm long, stigma obscurely 2-lobed. **Fruit** (May—August) a capsule, widely curved downward and inward, 4—6 cm long, 1—2 mm wide, very narrow, long-pointed, flattened parallel to dividing membrane inside, green to reddish tan, the sides 1-nerved toward base, completely splitting apart at maturity, not indented between seeds; **seeds** many, in one row in each of the two fruit chambers, about 1.5 mm long, about 1.2 mm wide, broadly oval, plump, wing none or < 0.05 mm wide toward far edge only; embryonic root at edges of and longer than cotyledons. Meiotic chromosome number unknown, probably a multiple of 7. (Morefield personal observations; Rollins 1941, 1982, 1993b).

Technical: **Perennial** herb to 5 dm high, hairs mostly minute, multibranched; **caudex** mostly loosely much-branched; **overall color** grayish-green to reddish-tan with pale purple flowers. **Stems** 20—50 cm long, cylindric, erect, usually many from base, simple or branched above, densely puberulent below, glabrate above. **Leaves** basal and cauline, alternate, flat, simple, entire, erect; basal leaves tufted, many, 1.5—5 cm long, 1.5—3.5 mm wide, linear to

narrowly oblanceolate, acuminate, 1-nerved, petioled, evenly and densely whitish- to grayish-puberulent; cauline leaves few, sparse, sessile, 0.8—3.5 cm long, 1.5—3 mm wide, oblong, acute, shortly auriculate, lower densely puberulent, upper less puberulent; **stipules** none. **Flowers** (April—June) erect, several in a loose terminal raceme, sepals and petals soon deciduous; **bracts** none; **pedicel** in fruit 7—10 mm long, spreading at right angles to stem, widely arched downward, puberulent to glabrous; **sepals** 4, separate, erect, about 3—4 mm long, about 1.5—2 mm wide, non-saccate, oblong, greenish to reddish tan, puberulent to glabrous, margin narrowly scarious; **petals** 4, separate, erect, 5—7 mm long, about 2—3 mm wide, narrowly spatulate, pale purple; **stamens** 6, 2 shorter than the rest, included; **ovary** superior; **style** in fruit 0.5—1 mm long, stigma obscurely 2-lobed. **Fruit** (May—August) a capsule, widely curved downward and inward, 4—6 cm long, 1—2 mm wide, linear, acuminate, flattened parallel to septum, green to reddish tan, valves 1-nerved below middle, completely dehiscent at maturity, not constricted between seeds; **seeds** many, uniseriate, about 1.5 mm long, about 1.2 mm wide, broadly oblong, plump, wingless or winged < 0.05 mm distally; radicle exceeding accumbent cotyledons. *n* unknown, probably *x* = 6. (Morefield personal observations; Rollins 1941, 1982, 1993b).

Field Characters: Like most *Arabis*, *A. falcifructa* is a relatively inconspicuous plant with minute identifying features, requiring close observation for correct detection and identification. It also occurs with other superficially similar species (appendix 2, figure 2), from which it is distinguished by its long-lived well-branched root crown, very narrow, very densely whitish- to grayish-hairy basal leaves, 2—5 dm tall stems, mature fruit curved widely outward and downward with styles 0.5—1 mm long, and nearly wingless seeds. *Arabis falcifructa* may be separated from similar or co-occurring taxa by the following key, which was synthesized from personal observations and from Rollins (1941, 1982, 1993a, 1993b). Only completely mature fruit should be used for identification.

1. Flower stalks bracted at base *or* calyx urn-shaped *or* petals not white to purple *or* petals > 15 mm long *or* unguiculate *or* fruit beaked *or* not completely splitting lengthwise at maturity *or* fruit not flattened parallel to septum *or* fruit < 7x longer than wide *or* fruit not stalked above calyx *or* radicles incumbent or oblique *or* old anthers coiled *or* leaves lobed *or* stem leaves none *or* plants annual.....other **Brassicaceae**
- 1' Flowers not bracteate; calyx not urn-shaped; petals white to purple, < 15 mm long, not unguiculate; fruit not beaked, completely splitting lengthwise at maturity, flattened parallel to septum, > 7x longer than wide, sessile above calyx; radicles accumbent; old anthers not coiled; leaves entire or dentate, cauline and usually basal; plants perennial or some biennial..... most **Arabis**
2. Fruit > 2 mm wide *or* fruit tip pointing upward or straight outward *or* base of fruit stalk pointing downward *or* leaves > 4 mm wide, oblanceolate to spoon-shaped *or* basal leaves fringed with hairs larger than those elsewhere *or* fruit stalks and upper leaves densely and minutely hairy other **Arabis**
- 2' Fruit < 2 mm wide, tip pointing downward, base of stalk pointing upward or straight outward, then curving downward; leaves < 4 mm wide, linear to narrowly oblanceolate, evenly hairy; fruit stalks and upper leaves sparsely hairy to hairless.
3. Basal leaves greenish, sparsely or coarsely hairy; base of fruit stalk pointing slightly upward**Arabis sparsiflora, cusickii**

- 3' Basal leaves gray to white, densely and finely hairy; base of fruit stalk pointing straight outward.
4. Mature fruit pointing straight downward or nearly so, blunt, style < 0.1 mm long; seeds winged all around, wing > 0.25 mm wide; petals < 5 mm long, white
*Arabis cobrensis*
- 4' Mature fruit curving widely out and downward, sharply pointed, style 0.5—1 mm long; seeds winged only near tip, wing < 0.05 mm wide; petals 5—7 mm long, pale purple.....*Arabis falcifructa*

Photographs and Line Drawings: No published photographs or line drawings are known for *Arabis falcifructa*. A composite line drawing, using sections of line drawings of *Arabis cobrensis* (by Linda Ann Vorobik, published in Hickman [1993]), and of *A. lignifera* A. Nelson and *A. holboellii* Hornemann var. *pinetorum* (Tidestrom) Rollins (by Jeanne R. Janish, published in Hitchcock and Cronquist [1973]), and approximating the appearance of *A. falcifructa*, was made for this report and is reproduced in appendix 2, figure 1. Line drawings of two related species easily confused in the field are reproduced in appendix 2, figure 2. Photographs made for this report are reproduced in appendix 2, figures 3—5, and are filed with the Nevada Natural Heritage Program.

V. SIGNIFICANCE OF TAXON

Natural: *Arabis falcifructa* is unusual in its apparent restriction to soils with dense covers of moss, and could be important in studying ecologic relationships and life-cycle dependencies between vascular and non-vascular plants. Like other plant species growing in its habitat, it contributes to soil formation and retention, nutrient cycling, and biomass production. Because of its close relationship to other *Arabis* species, and its apparently recent origin from one or more of those species, *A. falcifructa* represents an important tool for studying speciation, gene flow, and genetic diversity among isolated and possibly self-pollinating or apomictic populations of *Arabis*, and represents a key segment of the genetic diversity within the group of taxa allied to *A. cobrensis*.

Human: No studies of medicinal or other qualities of potential human benefit are yet known to have been performed on *Arabis falcifructa*. As a non-weedy member of the mustard family, it is closely related to numerous noxious, injurious, and invasive weed species such as tall whitetop (*Lepidium latifolium* Linnaeus), whitetop (*Cardaria pubescens* [C. Meyer] Jarmolenko), and tumble mustard (*Sisymbrium altissimum* Linnaeus). Species like *Arabis falcifructa* could be important as future sources of genetic material for use in reducing the invasive abilities of weedy species.

VI. GEOGRAPHIC DISTRIBUTION

Geographic Range: (appendix 1, table 1; appendix 3 maps). Globally, *Arabis falcifructa* has been documented only in Nevada, from 9 sites in 3 scattered groups in the Salmon Falls Creek basin between Thousand Springs and Jackpot, Elko County, and in the Shoshone Mountains northwest of Austin in Lander County (map 1), almost entirely on public lands

administered by the U. S. D. I. Bureau of Land Management (BLM). *Arabis falcifructa* probably also occurs in extreme southern Idaho and possibly in northwestern Utah.

Precise Occurrences: Site numbers and descriptions are given in appendix 1, tables 1—2, and site maps are presented in appendix 3. The tables cross-reference each site to its related maps and figures, and to its source(s) of documentation and most recent year observed. Population boundaries were mapped to the greatest precision possible in the field. Numbers of individuals in small populations were estimated by direct counting, and in larger populations by extrapolation of density samples to the mapped area of the population. The areas, elevation ranges, and land management information given in tables 1—2 were derived from the final mapped population boundaries. Threats and impacts were assessed from all available information, including but not limited to visual inspection on the ground, and association with mapped disturbances.

To the best of my knowledge, no privately managed sites were entered upon to obtain any of the new information documented by these surveys against the restrictions of the owners or managers. In some cases, private sites were small and easily viewed and documented from adjacent public lands or public access areas. In a few cases, sites were not surveyed due to lack of access, and the information in this report is then based solely on any previously existing information.

Historical site(s) rediscovered or recently known extant: (appendix 1, table 1) Prior to 1991, *Arabis falcifructa* was documented or reported from 3 populations (sites 1—3), which are here considered to be the historical sites for this species. Two of these were subsequently rediscovered and further documented. Site 1 (the type locality) could not be relocated during surveys for this report because of imprecise prior documentation, but disturbance in the region likely containing this site is minimal enough that the site can still be presumed extant. The historical populations are now estimated to comprise 288 individuals covering about 10.1 acres (4.1 ha) of BLM lands and possible Nevada Department of Transportation (NDOT) rights-of-way between 5300 and 6000 feet (1615—1830 meters) elevation. All other sites are considered new and are discussed below.

New site(s) discovered: (appendix 1, table 1) In 1991 and 1992, 6 new populations (sites 4—9) were discovered and documented, comprising about 318 individuals, and covering about 28.4 acres (11.5 ha) of BLM lands and possible NDOT rights-of-way between 5320 and 6100 feet (1620—1860 meters) elevation.

Historical site(s) searched for but not rediscovered: The type population (site 1) was imprecisely located in the historical records, and searches of the general area in 1991—2 did not relocate it. The marker on appendix 3, map 2 was placed on apparently suitable habitat at a location concordant with the historical data, and this site should be surveyed at the next possible opportunity. The actual site is likely within a 2—3 mile (3—5 km) radius of this marker. There were few new disturbances observed within this radius, and this population is therefore presumed extant until further documentation can be obtained.

Other site(s) searched where not discovered: (appendix 1, table 2) Sites U1—U17, comprising about 1043 acres (422 ha) between 5170 and 6245 feet (1575—1905 meters) elevation, were surveyed without encountering *Arabis falcifructa*. While previous botanic surveys have been conducted throughout much of Nevada, most of these were not focused on *Arabis falcifructa*. Much potential habitat remains unsurveyed in northeastern Nevada and southern Idaho, and complete surveys probably would increase the known population by about 2—10 times.

Historical site(s) known or suspected to be erroneous reports: No erroneous reports are known.

Historical site(s) known or assumed extirpated: No extirpations of *Arabis falcifructa* populations are known or suspected to have occurred. Highway construction, concentrated livestock grazing, and invasive weed infestations have occurred in historically appropriate habitat with the species' range, however, and these activities could have extirpated one or more undocumented populations prior to knowledge of conservation concerns for the species. Site 8 appears nearly extirpated due to livestock trampling.

Historical site(s) where present status unknown: The type locality (site 1) was presumed still extant based on conditions observed in the area where it likely occurs, but its current status could not be documented. Further searches are needed to document and assess this site.

Potential site(s) meriting future field surveys: Several hundred to several thousand acres of potential habitat for *Arabis falcifructa* remain unsurveyed in northeastern Nevada and southern Idaho based on observation made during surveys for this report, but could not be visited. Based on the percentage of potential habitat found to be occupied thus far, surveys of all remaining potential habitat would probably increase the existing population estimates by about 2—10 times.

VII. HABITAT CHARACTERISTICS

Environment and Habitat Summary: (appendix 2, figures 3—5) *Arabis falcifructa* appeared essentially restricted to light-colored silty soils with a high cover of moss, derived from volcanic ash and tuff deposits on dry, vegetated, relatively undisturbed, moderate to steep northerly aspects between 5300 and 6100 feet (1615—1860 meters) elevation. The report of rock-crevice habitat at the type locality (site 1; Rollins 1982) has not been confirmed, but is reasonable to expect at least occasionally for any *Arabis* species. The habitat supported a relatively dense shrub-steppe association usually dominated by moss, Wyoming sagebrush (*Artemisia tridentata* var. *wyomingensis*), pinyon rabbitbrush (*Chrysothamnus viscidiflorus* var. *puberulus*), hopsage (*Grayia spinosa*), western bluegrass (*Poa secunda* var. *secunda*), Indian ricegrass (*Achnatherum hymenoides*), cushion buckwheat (*Eriogonum ovalifolium* var. *ovalifolium*), and several other species (appendix 1, table 3).

Physical Characteristics:

Physiography: The known sites of *Arabis falcifructa* lie in the southwestern Central Great Basin and northwestern Bonneville Basin sections of Holmgren's (1972) Great Basin Division of the *Intermountain Flora* region. These correspond to Fenneman's (1931) Great Basin Section of the Basin and Range Province. The Central Great Basin Section is a high mountainous region characterized by sagebrush-dominated valley floors generally elevated above 5000 feet (1520 meters), and mountain ranges dominated by non-calcareous rock types (Holmgren 1972). The northeastern Bonneville Basin Section drains into the Snake River, is sometimes considered part of the Columbia Plateau region, and is similar to the Central Great Basin Section except for the smaller, lower, less distinct mountain ranges with a higher proportion of volcanic deposits. The Great Basin Division consists of a series of mostly north-south-oriented ranges and basins block-faulted from rocks that age progressively toward the northwest and that have been arched upward in the middle.

Climate: Hidy and Klieforth (1990) aptly described the climate of the Great Basin as "... one of the most extreme and variable climates on earth." This high variation occurs along horizontal and elevational gradients and at all time scales: hourly, daily, seasonally, annually, and over the tens of thousands of years of glacial cycles. The region's latitude, interior continental position, and high mountainous borders combine to create a generally arid climate. As in most arid regions, evapotranspiration greatly exceeds precipitation at all elevations, producing an average net loss of surface moisture (Hidy and Klieforth 1990). Most annual precipitation falls from about November through April in Pacific storm systems from the west. The Great Basin also lies within the influence of sub-tropical summer moisture, which originates in the Gulfs of Mexico and California and spreads over most of Arizona during July and August. This "monsoonal" influence produces a secondary peak of precipitation particularly toward the eastern and southern parts of the region, averaging about a quarter to half of the annual total, and capable of delivering a substantial majority of annual precipitation to limited areas in any given year. Both summer and winter precipitation are highly variable from year to year, ranging between about 25% and 250% of the long-term averages. Variability decreases somewhat toward the northeast and at higher elevations.

Temperature variations range up to 40—50°F (22—28°C) in daily changes, in average differences between warmest and coldest months, and in departures of extreme highs and lows from seasonal averages (Hidy and Klieforth 1990, Holmgren 1972, Morefield personal observations). This can result in differences up to 120—140°F (67—78°C) in the extremes experienced at any one site during a year. In general, temperature ranges at all the above scales tend to increase toward lower elevations and toward the northeast part of the region. Daily variations further tend to be greatest at the lowest humidities during the spring and fall seasons. The average daily temperature range throughout the year is about 25—30°F (14—17°C).

The elevations where *Arabis falcifructa* populations occur presently experience warm, dry summers and cold moist winters. Annual precipitation averages about 9—12 inches (230—305 mm), with about 25—40% falling as snow. Temperatures average about 64—71°F (18—22°C) in July and 21—30°F (-6 to -1°C) in January (values estimated from public climatic data available from the Western Regional Climate Center, Reno, Nevada). Drier and warmer than average conditions prevailed during surveys for this report.

Geomorphology, aspect, and slope: All populations are restricted to moderate to steep, slightly concave northwest to northeast aspects of low hills and knolls, on which all positions from top to bottom appear to be occupied without further preference. The cooler soil temperatures and enhanced moisture collection and retention of such slopes likely provide optimal growing conditions for *Arabis falcifructa* and for the soil moss species on which it appears to depend.

Geology: The soils at all sites surveyed for this report were observed to be composed primarily of silty material derived from tuffaceous sedimentary deposits. All *Arabis falcifructa* sites in Elko County are shown by Coats (1987) to be underlain by Upper Tertiary sedimentary and volcanic rocks, mainly of the Humboldt Formation, the lower half of which consists mostly of ash and tuff deposits. These deposits are widespread at the elevations occupied by *Arabis falcifructa* in northeastern Nevada, and likely support much additional habitat for the species.

Soils: Almost all sites appear to have deep, silty, well-drained soils derived from underlying soft tuffaceous sediments, with a relatively high organic content further augmented by a dense surface moss cover. Rollins (1982) reported that at least part of the type collection at site 1 came from crevices of an unknown rock type. While *Arabis falcifructa* appeared to prefer slopes with well-developed soils, at least occasional occurrence on rock outcrops is typical of most *Arabis* species and could be expected for *A. falcifructa* as well. Rock outcrop habitats are relatively scarce within the currently known range of *Arabis falcifructa*.

Hydrology: *Arabis falcifructa* was not associated with free water, and was entirely dependent on retention of incident precipitation in the soil and by the soil-surface moss cover. *Arabis falcifructa* occurred on slightly concave landforms which served to somewhat concentrate precipitation runoff and snowdrift, resulting in a slightly higher moisture supply relative to surrounding sites. The Elko County sites were all in an open basin drained by Salmon Falls Creek, then by the Snake and Columbia rivers. The Lander County site was in a closed basin terminating at Humboldt Sink, and was drained by Antelope Creek, then by the Reese and Humboldt rivers.

Air and water quality requirements: No specific requirements or unusual tolerances are known. Local airborne dust concentrations caused by livestock traffic or other disturbances could negatively impact *Arabis falcifructa* and even more likely the soil-surface moss on which it appears to depend.

Biologic Characteristics:

Community physiognomy: *Arabis falcifructa* occurred scattered in a relatively tall and dense shrub-steppe association, with significant grass and moss covers, within the big sagebrush zone typical of the valleys and foothills of the Great Basin.

Vegetation type: *Arabis falcifructa* occurred in a relatively tall and dense phase of Wyoming sagebrush (*Artemisia tridentata* var. *wyomingensis*) shrub-steppe commonly found on concave or otherwise slightly mesic microsites. This is one of the most abundant vegetation types within the range of *Arabis falcifructa*, and is a member of the big sagebrush series of Sawyer and Keeler-Wolf (1995).

Associated plant species: (appendix 1, table 3) An unidentified soil-surface moss, *Artemisia tridentata* var. *wyomingensis* (and often *A. nova*), *Chrysothamnus viscidiflorus* var. *puberulus*, *Poa secunda* var. *secunda*, and *Eriogonum ovalifolium* var. *ovalifolium* occurred at all sites where associates were documented. *Grayia spinosa*, *Achnatherum hymenoides*, *Leptodactylon pungens*, *Opuntia erinacea*, *Pediocactus simpsonii*, *Elymus elymoides*, and *Phlox hoodii* were frequently observed also.

Other endangered, threatened, and sensitive species: At least 11 other sensitive plant and animal species are known in and near the range of *Arabis falcifructa*, and are listed in appendix 1, table 4. Habitat for all five plants listed is known to occur within or adjacent to *Arabis falcifructa* sites. Once any pollinators of *Arabis falcifructa* become known, any that prove to visit this or other rare plant species exclusively could also be regarded as sensitive.

Land Management: (appendix 1, table 1) For all sites, management status was determined based on the best maps and other information available, but generally was not further verified. Ownership status of associated minerals and water rights was not determined for any site, nor was the presence or absence of any easements or other encumbrances.

Bureau of Land Management (BLM), U. S. Department of the Interior: At least 99% of the global *Arabis falcifructa* population occurred on public lands managed by BLM's Elko and Battle Mountain districts. All of these lands appeared to be managed for multiple uses, and were open to and used for extractive activities such as livestock grazing and mineral exploration and development. *Arabis falcifructa* is designated as a sensitive Special Status Species by the U. S. D. I. Bureau of Land Management (1996, 1997), but no further special management for the species is known to exist.

Nevada Department of Transportation (NDOT): Sites 2 and 6 near San Jacinto occurred between current U.S. Highway 93 and an older abandoned right-of-way, and portions of these populations may therefore be under NDOT management. Indeed, construction and maintenance in these rights-of-way may have permanently eliminated portions of these populations prior to knowledge of conservation concerns for *Arabis falcifructa*. Future road maintenance or expansion activities

could further impact these populations. NDOT regularly consults the Nevada Natural Heritage Program for knowledge of sensitive species occurrences prior to such projects, but decisions to avoid, mitigate, or impact sensitive populations are made on a case-by-case basis.

VIII. BIOLOGY AND ECOLOGY

Population Summary: Based on the information gathered for this report, the total known global population of *Arabis falcifructa* was estimated to be 606 individuals, and to occupy about 38.5 acres (15.6 ha) of habitat divided among 9 populations in 3 scattered groups in the Salmon Falls Creek basin of northeastern Elko County and in the Shoshone Mountains of southwestern Lander County, Nevada, between 5300 and 6100 feet (1615—1860 meters) elevation (appendix 3, map 1). Based on the probable extent of unsurveyed potential habitat, the true total population of *Arabis falcifructa* is estimated to be 2—10 times greater than that now documented.

Demography: Long-term monitoring has not been conducted for *Arabis falcifructa* populations to determine demographic trends. Absence of the species from numerous apparently suitable sites provides circumstantial evidence that the species may have undergone population declines at least during prehistoric times, and/or that it may have limited ability to disperse and to establish new populations in unoccupied habitat.

The surface area covered by the root crown of each individual probably increases each year according to the resources available for new production and its ability to process those resources, providing a rough measure by which age classes could be separated within a population. There is no known way to precisely age an individual, however, or to compare age class distributions between different populations. Most populations observed consisted of about 70—95% large, well-established plants at least several years in age. Up to about 5% seedlings were observed, and the remainder were either juvenile or senescent plants. At least in undisturbed populations, plants of *Arabis falcifructa* appear to be relatively long-lived, in the range of 10—30 years, with low rates of recruitment of new individuals.

From estimates of the total individuals within total occupied habitat (see population summary, above), an average density of 15.7 plants per acre (38.8/ha) can be estimated. However, individual site estimates ranged from about 1.8 plants per acre (4.4/ha; site 8, the most disturbed site) to about 105 plants per acre (260/ha; site 2; appendix 1, table 1).

Phenology: Because of the need to survey populations and collect specimens when mature fruit is present for reliable identification, the flowering phenology of *Arabis falcifructa* can only be speculative until more extensive monitoring data can be gathered. Specimens have been gathered between 30 May and 27 July of various years, and while most of these likely had mature fruit, flowers were described by Rollins (1982) and therefore must have been present on some of the earliest gatherings. Populations in full fruit were observed in the first week of June during an unusually warm and dry year (1992) during surveys for this report, and in the last week of July 1991 all plants had at least partially shed their seeds.

Like most other mustard family members, new leaves and flowering stems likely emerge soon after snow cover is gone and soil temperatures are high enough. Depending on the timing and amounts of precipitation and temperature changes, flowering probably begins sometime between late April and mid-May and continues sporadically to mid-June. The fruit probably mature by about a month after flowering, between late May and mid-August.

Genetics: No studies of the genetic structure in *Arabis falcifructa* are known. Most *Arabis* species appear to reproduce from seed produced variously by insect-mediated pollen exchange between flowers of the same or different plants, by self-pollination, or sometimes by apomixis (directly from unreduced, diploid gametes). The floral display of *Arabis falcifructa* is probably sufficient to attract insect pollinators, but the scattered, low-density populations may limit reproductive success by this means. Its likely genetic structure therefore cannot be determined. If major disturbances or other impacts to *Arabis falcifructa* habitat become a critical threat to population viability in the future, the genetic structure of the species and its populations should be studied in order to guide the most effective possible conservation strategies.

Reproduction and Dispersal: No studies of reproduction or dispersal are known for *Arabis falcifructa*. As discussed above under Genetics, insect-mediated outcrossing, self-pollination, and apomixis are all possible reproductive strategies for *Arabis falcifructa*. No insect pollinators could be observed during surveys for this report due to the absence of flowering stages. Because its seeds fall directly from the fruit while still attached to the parent plant, gravity is probably the primary dispersal agent for the species, limiting initial dispersal distances to a meter or less, or perhaps to a few meters during high wind events. Occasional surface water runoff likely plays a secondary role once seeds are on the ground, moving seeds an additional few meters down-slope.

Hybridization: As discussed earlier, plants of *Arabis cobrensis*, *A. falcifructa*, and *A. sparsiflora* var. *sparsiflora* were found growing intermingled at the Thousand Springs Valley 5973 site (site 9), and one plant assigned to *A. sparsiflora* var. *sparsiflora* exhibited some characteristics intermediate with *A. falcifructa*. Because of the relatively low numbers and densities of the *Arabis* populations at this site, it was impossible to determine whether this represented secondary contact between two previously distinct taxa, or an intermediate population in a zone of primary contact between two incompletely divergent forms. This did, however, suggest that *Arabis falcifructa* could have originated from ancient hybrids between the other two species, thereafter evolving into a separate, isolated species. *Arabis falcifructa* is intermediate between *A. cobrensis* and *A. sparsiflora* in several characters. Other than this isolated observation, no further evidence of hybridization between *Arabis falcifructa* and any other species was observed, despite its occurrence with several closely related *Arabis* species (appendix 1, table 3).

Pathology: No disease affecting *Arabis falcifructa* was observed or reported. Rust fungi are known to infect populations of many other *Arabis* species, and may occasionally affect *A. falcifructa* populations as well.

Predation: No evidence of significant herbivory or other predation was observed. Rabbits and other native fauna probably graze the leaves and flowering stems on an occasional basis without significant impacts. A band of sheep moving directly across a population could cause significant predation impacts. Impacts from cattle use appear to result primarily from substrate disturbance rather than predation.

Competition: At all sites *Arabis falcifructa* grew in close association with several other species in a relatively dense shrub/grass/moss association, and did not show the preference for reduced competitive pressures typical of many other rare plant species in arid regions (Fowler 1986, Gurevitch 1986). *Arabis falcifructa* usually grew directly out of large patches of a soil moss, on which it may at least partially depend for success at one or more life stages (Beymer and Klopatek 1992, Lesica and Shelly 1992). *Arabis falcifructa* may not tolerate much competition with itself, however, as suggested by its low population densities generally averaging about 40 per acre on relatively undisturbed sites.

Response to Disturbance: *Arabis falcifructa* did not appear to tolerate significant ground disturbance in its habitat, particularly from livestock trampling. As shown in appendix 1, table 1, all four documented sites with densities under 10 plants per acre had experienced significant near-term impacts from trampling by grazing livestock, while impacts at the four remaining higher-density sites were either absent or due to other less detrimental causes. This probably comes from a dependency on high soil moss cover at one or more life stages (Lesica and Shelly 1992) and the rapid loss of such cover known to result from concentrated livestock trampling (Beymer and Klopatek 1992). Unlike many other rare species, *Arabis falcifructa* was never observed temporarily colonizing recent disturbances of any kind within its habitat.

Other Interactions: *Arabis falcifructa* was found exclusively at sites with relatively high covers of a common, unidentified soil-surface moss, and individual plants almost always grew directly out of patches of this moss (appendix 2, figures 3—5). This suggests the likelihood that *Arabis falcifructa* depends on the presence of this moss for success at one or more stages of its life cycle. Other cryptogamic soil crusts are known to enhance germination and/or establishment of seedlings, and/or subsequent survival of juvenile or mature plants of various species (Beymer and Klopatek 1992). Lesica and Shelly (1992) found the effect to be primarily on survival of older juvenile and adult plants of *Arabis fecunda* Rollins, but the exact effects of moss cover on *Arabis falcifructa* cannot be determined without further study.

IX. EVIDENCE OF THREATS TO SURVIVAL

Causes of impacts and threats observed or reported for the known sites are summarized in appendix 1, table 1.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range:

Animal grazing or trampling: All known *Arabis falcifructa* sites appeared open to and used for livestock grazing, which presently is the dominant land use within its

range, and the primary threat to its survival. There appeared to be little impact to *Arabis falcifructa* plants from direct herbivory, and its palatability to livestock remains unknown. A direct and strong correlation was observed between recent livestock trampling and low densities of *Arabis falcifructa* and its associated soil-surface moss, very likely resulting from the fragility and long regeneration time of the latter (Beymer and Klopatek 1992, Lesica and Shelly 1992). The Eagle Flat SE population (site 8) appeared to have been nearly extirpated by concentrated livestock use. The Savory (1988) method of short-term, concentrated livestock grazing, supposed to stimulate plant germination and growth, enjoys increasing acceptance among land and livestock managers. Such methods would likely be highly destructive to *Arabis falcifructa* populations, however, and would likely promote the invasion of weedy annual species in the sagebrush ecosystems it inhabits.

Mineral exploration and development: Most of the areas in which *Arabis falcifructa* populations were found had few or no known mineral resources of economic value. Claim posts for unknown deposits were observed only at the Shoshone Mountains site (site 3). Established or historic gravel pits existed near several of the Elko County populations near U.S. Highway 93, and presumably serve(d) as material sources for highway construction and maintenance. Mineral or materials extraction is unlikely to prove a major threat to *Arabis falcifructa*, but the possibility of a new gravel or mineral operation impacting an existing population will always remain under current mining laws.

Road development and maintenance, and ORV use: Most *Arabis falcifructa* populations located so far occurred near highways or other unpaved roads, and are vulnerable to future development and maintenance of these roads, and to off-road vehicle or livestock traffic facilitated by road access. Few road-related impacts have yet been observed, but historic portions of sites 2 and 6 near San Jacinto may have been extirpated by construction activities associated with U.S. Highway 93.

Fire, fire suppression activities, and invasion of exotic plant species: No fire-related impacts have yet been observed at *Arabis falcifructa* sites. Historic suppression of natural fire, however, coupled with the recent rapid spread of invasive, fire-maintained exotic weeds that require further fire suppression, pose a major threat to *Arabis falcifructa* habitat. The suppression-related buildup of fuel has increased the likelihood of large, destructive fires that could affect several *Arabis falcifructa* populations at once, and that could result in permanent replacement of the habitat by annual cheatgrass (*Bromus tectorum* Linnaeus) grasslands. Fire suppression activities themselves pose a major risk as well, similar to that of livestock trampling, if carried out within the habitat. Fortunately, cheatgrass has not yet been detected at any *Arabis falcifructa* site, and few other exotic species were observed (appendix 1, table 3).

Over-utilization for Commercial, Recreational, Scientific, or Educational Purposes: The few small scientific collections that have been taken to document populations (appendix 1, table 5) are neither known to nor likely to have had significant impacts on any population of the species. No other uses of the species for such purposes are known.

Disease or Predation: Other than the livestock activity discussed above, no significant disease or herbivore damage was noted at any of the sites.

Inadequacy of Existing Regulatory Mechanisms: No enforceable protective designations, conservation agreements, or approved management plans are known to exist for *Arabis falcifructa* or its habitat. Unless it is listed as endangered or threatened (50 CFR 17.61, 17.71) and occurs within federal jurisdiction, a plant has no formal protection under the federal Endangered Species Act (ESA), except for regulatory determinations by some federal agencies (U. S. Forest Service, Bureau of Land Management) that candidate and other sensitive species will be managed in order to avoid the need for listing. No federal protection currently extends to plants under non-federal jurisdiction unless they are listed as endangered and removing, cutting, digging up, damaging, or destroying them would be "*in knowing violation of any law or regulation of any state or . . . of a state criminal trespass law*" [ESA Sect. 9(a)2(B)], and that law applies to non-federal jurisdictions. It should also be noted that the Endangered Species Act and the various agency regulations implementing it are in direct conflict with provisions of the mining law of 1872 (30 U.S.C. 21 *et seq.*), and are therefore of uncertain protective value when mineral-related projects are involved.

The recent elimination of category-2 candidate status and tracking by the U. S. D. I. Fish and Wildlife Service (1996) removed a source of centralized and coordinated oversight for hundreds of species still considered potentially vulnerable, including *Arabis falcifructa*. Most of these species continue to be tracked and treated as sensitive by the Bureau of Land Management, U. S. Forest Service, state natural heritage programs, and other agencies. The long term impact of this change, however, remains unknown but potentially detrimental as agency policies and procedures go their separate ways, and budgets and priorities change. This could accelerate the need to list some former category-2 candidates as threatened or endangered.

U. S. D. I. Bureau of Land Management (BLM) policy provides that the agency "*shall carry out management, consistent with the principles of multiple use, for the conservation of candidate species and their habitats and shall ensure that actions authorized, funded, or carried out do not contribute to the need to list any of these species as Threatened or Endangered.*" If a candidate species occurs entirely on federal lands, BLM policy further requires that it be included as a priority species in land use plans, and that range-wide or site-specific management plans be prepared "*that identify specific habitat and population management objectives designed for recovery, as well as the management strategies necessary to meet those objectives*" (BLM Manual Section 6840). Although *Arabis falcifructa* is no longer a candidate for Federal listing, the Nevada State Office of BLM has designated most former candidates, including *A. falcifructa*, as Sensitive Species, thus requiring management as candidate species (U. S. D. I. Bureau of Land Management 1996, 1997). No management plans specific to *Arabis falcifructa* are known to exist, however, and the effectiveness of such plans would still depend upon adequate implementation and enforcement resources.

Arabis falcifructa is not listed as "critically endangered" under Nevada Revised Statutes (NRS) 527.270. Such listing would provide that ". . . no member of its kind may be removed or destroyed at any time by any means except under special permit issued by the state forester

firewarden" on any lands in Nevada. The adequacy of this law, however, depends on informed and cooperative land managers, or on some form of deterrent enforcement, for either of which the current law does not provide. It also depends on the state forester firewarden's discretion in issuing or withholding permits, and in placing protective conditions on permits that are issued. Nevada law does not mandate the continued survival of any plant species which it declares to be in danger of extinction.

Other Natural or Man-made Factors: To the extent that *Arabis falcifructa* may depend upon insect pollinators for successful reproduction, any natural or man-made factors affecting the viability of such insects would also affect the viability of *A. falcifructa*. The small, low-density populations are vulnerable as well to random fluctuations that could occasionally result in natural extirpations.

X. GENERAL ASSESSMENT AND RECOMMENDATIONS

General Assessment: As now known, the global population of *Arabis falcifructa* consists of about 606 individuals restricted to about 38.5 acres (15.6 ha) of public lands divided among 9 populations occupying 3 scattered areas in the Salmon Falls Creek basin and the Shoshone Mountains of northeastern Elko and southwestern Lander counties, Nevada. *Arabis falcifructa* appears to be a valid, distinct species closely related to *A. cobrensis* and *A. sparsiflora*. The species is restricted to light-colored silty soils with a high cover of moss, derived from volcanic ash and tuff deposits on dry, vegetated, relatively undisturbed, moderate to steep northerly aspects (possibly including rock crevices at some sites), and is dependent entirely on incident precipitation. It occurs in low densities in a mesic microsite phase of Wyoming sagebrush (*Artemisia tridentata* var. *wyomingensis*) shrub-steppe communities. Several hundred to several thousand acres of potential habitat are believed to remain unsurveyed, and the true total population may be about 2—10 times larger than that now documented.

Because of its rarity, fragmented global range, small low-density populations, and ongoing impacts and threats, *Arabis falcifructa* remains vulnerable to human-caused extirpations in the short term which could, perhaps in combination with random natural events, lead to extinction in the long term. Existing impacts to the species affect six (67%) of the 9 known populations, and had nearly extirpated at least one (11%) population where concentrated livestock trampling had occurred. Two additional (22%) impacted sites had so few plants as to be of questionable viability, but it could not be determined whether the human-caused impacts were responsible. *Arabis falcifructa* habitat is highly vulnerable to and threatened by concentrated livestock traffic throughout its range. Road development and maintenance, and wildland fires with associated fire-suppression activities and invasive weed infestations, are also significant threats to most known populations. Threats from all these sources will exist indefinitely under present circumstances, but could be substantially reduced through appropriate management actions and further surveys.

Status Recommendations: Until recently *Arabis falcifructa* was classified as a category-2 candidate for listing by the U. S. D. I. Fish and Wildlife Service (1993). That category was eliminated on 28 February 1996 (U. S. D. I. Fish and Wildlife Service 1996). Based on the

best available scientific evidence and the likelihood that additional populations exist, the species does not yet meet the definition of a candidate for listing as threatened or endangered under the Endangered Species Act, but would meet that definition if additional surveys revealed few or no additional populations. More surveys are needed immediately. With further surveys, appropriate long term monitoring, and cooperation in management of habitat disturbance, human-caused extirpation or extinction can be avoided. Absent such management, the long-term possibility of extinction or major declines will remain, and federal or state listing could become justified if one or more of the known populations were lost to preventable causes.

The species is also designated a Special Status (Sensitive) Species by the U. S. D. I. Bureau of Land Management, is ranked 1 (critically imperiled) at the global and state levels by the Nevada Natural Heritage Program, and is on the Watch list of the Northern Nevada Native Plant Society (NNNPS). Because of the somewhat expanded number of known populations, but continued presence of significant impacts and threats to several populations, the Nevada Natural Heritage Program's Global and Nevada ranks for *Arabis falcifructa* should be changed from 1 to 1—2. No other changes in status are recommended.

Critical Habitat Recommendations: If critical habitat were ever designated through the provisions of the Endangered Species Act or any other law or regulation, it should include all populations then known, plus any additional suitable habitat contiguous with those populations, plus an additional 250-foot (75-meter) horizontal buffer zone. Critical habitat should not be formally designated in cases where it might subject *Arabis falcifructa* to increased threats to its survival, would interfere with habitat management, or would subject managers of the habitat to problems of trespass by curiosity seekers.

Conservation and Recovery Recommendations: The following recommendations, roughly in descending order of priority, are offered as the best opportunities to maintain the long-term viability of *Arabis falcifructa*, to avoid any future need to list it as threatened or endangered, and to reduce the overall long-term management costs for the species. They generally do not take into account limited agency resources or other conservation priorities, which may preclude implementation of some recommendations. If monitoring and additional surveys (outlined in recommendations 1, 2, and 4) indicate that further preventable declines in viability of the species are occurring, more aggressive conservation and recovery measures should be identified and pursued.

1. The Bureau of Land Management (BLM) should work with grazing permittees to ensure that only dispersed grazing activity occurs in and near known populations. Stock driveways and placement of salt blocks, watering sources, or other range supplements likely to concentrate animals in small areas, should be prohibited within 0.25 mile of any known population as part of permit requirements. Close compliance monitoring should be conducted at least annually.
2. BLM should conduct or require additional surveys, following recognized professional standards (Nelson 1994), for undocumented *Arabis falcifructa* populations prior to implementation of projects or directives, particularly those likely to create

concentrated animal trampling, in and near potential habitat of the species, and any new populations found should be thoroughly documented. Impacts to new populations should be avoided or minimized during project implementation. Whenever funding and personnel permit, similar surveys should be continued outside of the project evaluation process as well.

3. The Nevada Department of Transportation (NDOT) should assess their rights-of-way near the known populations for actual presence of the species, and should design future construction, maintenance, and vegetation/weed control projects to avoid further impacts to such populations.
4. In conjunction with grazing compliance checks recommended above, BLM should field-check all *Arabis falcifructa* sites at least every 2 years, and more often where significant impacts have previously occurred or are reasonably foreseeable, to detect any new or intensified impacts, and should take immediate steps to eliminate and correct any such impacts. Field checks should include field tours for appropriate personnel to familiarize them with the plant and its habitat. If extirpations or new significant impacts become likely for one or more of the known populations, the survey efforts outlined in item 2 above should be intensified until all potential habitat has been examined, and impacts should be delayed at least until surveys are complete.
5. BLM should develop, implement, and adequately fund a long-term species management plan and conservation strategy for *Arabis falcifructa*, to address at a minimum all the other recommendations above and below, in consultation and participation with the Nevada Department of Transportation (NDOT).
6. BLM should aggressively manage and control invasions of exotic weeds within the range of *Arabis falcifructa*, in cooperation with adjacent landholders and managers, to help reduce fire hazards to more natural levels, thereby helping minimize the need for fire suppression activities within *A. falcifructa* habitat, and reducing seed sources for post-fire invasions of habitat by exotic species.
7. BLM should plan future fire-suppression actions and strategies, including identifying potential sites for fire breaks, access roads, landing pads, etc., to avoid or minimize impacts to known *Arabis falcifructa* populations.
8. Any future artificial revegetation actions in and near the range of *Arabis falcifructa* should attempt to use only plant species native to the local area, consistent with reasonable measures to exclude invasive exotic weed species from the area. BLM and any other agencies anticipating the need for artificial revegetation should plan in advance of reasonably foreseeable needs to ensure sufficient sources and/or supplies of native-species seeds. In appropriate cases, other species documented not to persist under local conditions may be added at non-competitive levels for temporary stabilization until the native species can establish.

9. Studies of pollinator populations, and their role in the reproductive success of *Arabis falcifructa*, should be encouraged and supported. If found to play a significant role, pollinators should be monitored at least every 2—3 years to detect any downward trends that could contribute to reproductive failure in *Arabis falcifructa*, and the cause(s) and possible remedies of any such declines should be assessed.
10. If the loss of more than 10% of the populations known at any given time becomes likely due to preventable causes, the U. S. D. I. Fish and Wildlife Service should consider protecting *Arabis falcifructa* under the Endangered Species Act by listing it as threatened or endangered.

XI. INFORMATION SOURCES

Literature Cited:

- Barneby, R. C. 1989. Fabales. pages 1-279 in: Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. *Intermountain Flora* vol. 3, part B. Bronx: The New York Botanical Garden.
- Beymer, R. J. and J. M. Klopatek. 1992. Effects of grazing on cryptogamic crusts in pinyon-juniper woodlands in Grand Canyon National Park. *American Midland Naturalist* 127: 139—148.
- Coats, R. R. 1987. Geology of Elko County, Nevada. *Nevada Bureau of Mines and Geology Bulletin* 101: 1—112.
- Cronquist, A. 1988. *The evolution and classification of flowering plants*, second edition. Bronx: The New York Botanical Garden.
- Cronquist, A. 1994. Asterales. pages 1-496 in: Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. *Intermountain Flora* vol. 5. Bronx: The New York Botanical Garden.
- Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal. 1972. *Intermountain Flora* vol. 1. New York: Hafner Publishing Company.
- Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1977. *Intermountain Flora* vol. 6. The Monocotyledons. New York: Columbia University Press.
- Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1984. *Intermountain Flora* vol. 4. Subclass Asteridae (except Asteraceae). Bronx: The New York Botanical Garden.
- Cronquist, A., N. H. Holmgren, and P. K. Holmgren. 1997. *Intermountain Flora* vol. 3, part A. Subclass Rosidae (except Fabales). Bronx: The New York Botanical Garden.

- Fenneman, N. M. 1931. *Physiography of the western United States*. New York: McGraw-Hill.
- Fowler, N. 1986. The role of competition in plant communities in arid and semiarid regions. *Annual Review of Ecology and Systematics* 17: 89—110.
- Gurevitch, J. 1986. Competition and the local distribution of the grass *Stipa neomexicana*. *Ecology* 67: 46—57.
- Hickman, J. C. (ed.). 1993. *The Jepson manual: Higher Plants of California*. Berkeley: University of California Press.
- Hidy, G. M. and H. E. Klieforth. 1990. Atmospheric processes affecting the climate of the Great Basin. pages 17-45 in: Osmond, C. B., L. F. Pitelka, and G. M. Hidy (editors). *Plant Biology of the Basin and Range. Ecological Studies* vol. 80. Berlin: Springer-Verlag.
- Hitchcock, C. L. and A. Cronquist. 1973. *Flora of the Pacific Northwest*. Seattle: University of Washington Press.
- Holmgren, N. H. 1972. Plant geography of the intermountain region. pages 77-161 in: Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal. *Intermountain Flora* vol. 1. New York: Hafner Publishing Company.
- Holmgren, P. K., N. H. Holmgren, and L. C. Barnett (eds.). 1990. Index herbariorum, part I: the herbaria of the world, 8th edition. *Regnum Vegetabile* 120: 1-693.
- Kartesz, J. T. 1987. *A flora of Nevada*. Reno: University of Nevada, unpublished doctoral dissertation.
- Lesica, P. and J. S. Shelly. 1992. Effects of cryptogamic soil crust on the population dynamics of *Arabis fecunda* (Brassicaceae). *American Midland Naturalist* 128: 53—60.
- Morefield, J. D. and T. A. Knight (eds.). 1992. *Endangered, threatened, and sensitive vascular plants of Nevada, December 1991*. Reno: U. S. Department of Interior, Bureau of Land Management, Nevada State Office. [with 15 January 1995 supplement from Nevada Natural Heritage Program, Carson City]
- Nelson, J. R. 1994. Guidelines for assessing effects of proposed developments on rare plants and plant communities. page 29 in: Skinner, M. W. and B. M. Pavlik (editors). *Inventory of rare and endangered vascular plants of California*. Sacramento: California Native Plant Society, Special Publication No. 1, fifth edition.
- Rollins, R. C. 1941. A monographic study of *Arabis* in western North America. *Rhodora* 43: 289—325, 348—411, 425—481.

- Rollins, R. C. 1982. Studies on *Arabis* (Cruciferae) of western North America. II. *Contributions from the Gray Herbarium of Harvard University* 212: 103—115.
- Rollins, R. C. 1993a. *Arabis*. *The Jepson manual*: 396—404 (ed. J. C. Hickman). Berkeley: University of California Press.
- Rollins, R. C. 1993b. *The Cruciferae of continental North America*. Stanford University Press.
- Savory, A. 1988. *Holistic Resource Management*. Covelo, California: Island Press.
- Sawyer, J. O. and T. Keeler-Wolf. 1995. *A manual of California vegetation*. Sacramento: California Native Plant Society.
- Thorne, R. F. 1992. Classification and geography of the flowering plants. *Botanical Review* 58: 225-348.
- Tiehm, A. 1996. Nevada vascular plant types and their collectors. *Memoirs of the New York Botanical Garden* 77: 1-104.
- U. S. D. I. Bureau of Land Management. 1996. *Nevada State Office instruction memorandum NV-96-019*. Reno.
- U. S. D. I. Bureau of Land Management. 1997. *Nevada BLM sensitive species list*. Reno.
- U. S. D. I. Fish and Wildlife Service. 1990. 50 CFR Part 17. Endangered and threatened wildlife and plants; review of plant taxa for listing as endangered or threatened species; notice of review. *Federal Register* 55: 6184-6229 (February 21).
- U. S. D. I. Fish and Wildlife Service. 1993. 50 CFR Part 17. Endangered and threatened wildlife and plants; review of plant taxa for listing as endangered or threatened species; notice of review. *Federal Register* 58: 51144-51190 (September 30).
- U. S. D. I. Fish and Wildlife Service. 1996. 50 CFR Part 17. Endangered and threatened wildlife and plants; review of plant and animal taxa that are candidates for listing as endangered or threatened species; notice of review. *Federal Register* 61: 7595-7613 (February 28).

Map Sources:

USGS 1:24,000 scale Topographic Series:

- Contact, Nevada (1989 provisional edition)
- Harris Canyon, Nevada (1982)
- Jackpot, Nevada—Idaho (1989 provisional edition)
- Knoll Mountain, Nevada (1968)
- Middle Stack Mountain, Nevada (1989 provisional edition)
- Mount Airy NE, Nevada (1969)

Vigus Butte NW, Nevada (1969)
Wilkins, Nevada (1968)
USGS 1:100,000 scale Topographic Series:
Edwards Creek Valley, Nevada (1983)
Jackpot, Nevada—Utah—Idaho (1982)
Wells, Nevada—Utah (1981)
BLM 1:500,000 scale Topographic Series, Surface Management Status
Nevada (State of) (1990)
Surface Geology:
Elko County, Nevada, 1:250,000 (Coats 1987, plate 1)

Field Research: Field surveys contributing information to this report were conducted by James D. Morefield on 25—28 July 1991 and 5—13 June 1992, and on 10 July 1997.

Specimens: All specimens known to document *Arabis falcifructa* sites are listed by site in appendix 1, table 5. The list was compiled from all available published and unpublished sources, but is not necessarily complete. Although new collections from previously documented sites are discouraged, the Nevada Natural Heritage Program welcomes further additions or corrections to this table as they become known.

Knowledgeable/Interested Individuals:

Janet Bair, Assistant Field Supervisor
Nevada State Office
U S Fish and Wildlife Service
1340 Financial Blvd, ste 234
Reno NV 89502
(775) 861 6320

Julie Ervin-Holoubek
Environmental Services Division
Nevada Department of Transportation
1263 S Stewart St ste 104
Carson City NV 89712
(775) 888 7689

Gail Bellenger
Environmental Services Division
Nevada Department of Transportation
1263 S Stewart St ste 104
Carson City NV 89712
(775) 888 7889

Noel H Holmgren
The New York Botanical Garden
Bronx NY 10458-5126
(718) 817 8646

Center for Plant Conservation
Missouri Botanical Garden
Box 299
St Louis MO 63166-0299
(314) 577 9450

Ray Lister, Wildlife Biologist
Elko Field Office
Bureau of Land Management
3900 Idaho St
Elko NV 89801
(775) 753 0200 x224

Michael Mancuso, Research Plant Ecologist
Idaho Conservation Data Center
600 S Walnut St
Box 25
Boise ID 83707
(208) 334-3402

Randy McNatt
Fisheries/Riparian/Rare Plant Coordinator
Bureau of Land Management
Nevada State Office
1340 Financial Blvd
Reno NV 89502
(775) 861 6473

James D Morefield, Botanist
Nevada Natural Heritage Program
Dept of Conservation and Natural Resources
1550 E College Pkwy ste 145
Carson City NV 89706-7921
(775) 687 4245

Larry Morse, North American Botanist
Science Division
NatureServe
1815 N Lynn St
Arlington VA 22209
(703) 841 5361

Jan Nachlinger
Forest Service Conservation Coordinator
The Nature Conservancy of Nevada
Northern Nevada Office
1 E 1st St ste 500
Reno NV 89501
(775) 322 4990

Nevada Native Plant Society
Box 8965
Reno NV 89507-8965

Jody Sawasaki, Botanist
Nevada State Office
U S Fish and Wildlife Service
1340 Financial Blvd ste 234
Reno NV 89502
(775) 861 6347

Frank J. Smith
Western Ecological Services
P.O. Box 422
Millville UT 84326
(435) 752-3534

Arnold Tiehm
1550 Foster Dr
Reno NV 89509
(775) 329 1645

Sylvia Torti, Conservation Biologist
Red Butte Garden and Arboretum
University of Utah
18C de Trobriand St
Salt Lake City UT 84113-5044
(801) 585-5853